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Original Article

Development of a New Fall Risk Assessment Index for Older Adults☆

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SUMMARY

Background: Falls are the third-leading cause of a bedridden state and are a major cause of morbidity in elderly people. Therefore, it is important to determine an older person's risk of falling using a simple and reliable method. The aim of the present study was to examine whether our newly developed index for the assessment of complex-task locomotion can predict falls in robust elderly people.
Methods: The new index consisted of four items (stand-up, turn, walk and trip tests). It was used to assess 780 community-dwelling elderly Japanese people (mean age 76.0 ± 7.4 years, 300 men and 480 women) who could complete a Timed Up and Go test in less than 13.5 seconds. We used receiver operating characteristic curves (ROC) to validate the index and to determine its cut-off point to predict falls.
Results: The area under the curve was 0.15 ($p < 0.001$, 95% CI: 0.675-0.755). The ROC curve analysis enabled the best cut-off (1 point) to discriminate fallers from non-fallers (sensitivity 80.8%, specificity 60.6%).
Conclusion: We have demonstrated that the new index is a reliable indicator for falls in elderly people who have higher levels of functional capacity. Our data suggest that a score of more than 1 point by the new index can predict falls in robust elderly people.

1. Introduction

In Japan, falls are the third-leading cause of a bedridden state and are a major cause of morbidity in older people[1]. Falls are relatively common among the elderly, with approximately 30% of individuals aged 65 years or older falling at least once a year[2]. Because falls tend to occur as a result of the activities of daily living, previous research has focused on identifying age-related changes in locomotive function[3]. Several performance measures, such as walking speed[4], Timed Up and Go (TUG) test[5], one-leg stand (OLS)[6], functional reach[7], five times chair stand[8], and Tinetti balance[9], have been used to evaluate the physical performance of community-dwelling older people.

Several studies have suggested that a cut-off point of 13.5 seconds in a TUG test is a useful indicator that an individual has an increased risk of falling[10]. However, some older adults who have higher levels of functional capacity can complete a TUG test in less than 13.5 seconds but remain susceptible to falls, so it is important to develop accurate prediction systems for these individuals. In daily-life situations, the requirements for locomotion typically occur under complicated circumstances with cognitive attention focused on a particular task. In recent years, numerous studies have evaluated complex-task locomotion for fall prediction in older adults[11–13]. However, more simple and reliable methods are necessary for elderly people living in the community.

The aim of the present study was to examine whether our newly developed index to assess complex-task locomotion was related to falls in the robust elderly population.

2. Methods

2.1. Participants

We recruited 780 community-dwelling elderly Japanese people (mean age 76.0 ± 7.4 years, 300 men and 480 women) for this study. We excluded participants based on the following exclusion criteria: the presence of severe cardiac, pulmonary or musculoskeletal disorders, co-morbidities associated with an increased risk of falls (i.e., Parkinson's disease or stroke), and a TUG score greater than 13.5 seconds. The simple TUG test was developed to screen

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basic mobility performance and has been shown to be significantly associated with activities of daily living function in frail older adults[5]. It has been reported that elderly people with a TUG score greater than 13.5 seconds are at increased risk of falling[10].

2.2. Questionnaire

The new index was developed in our university by a working group of medical doctors, physical therapists, occupational therapists, public health nurses and an epidemiologist. It consisted of four questions, rated as 0 or 1 by self-report as follows:(1) “Can you stand up without a support?” No = 1; (2) “Can you turn in the opposite way, while holding an empty glass?” No = 1; (3) “Can you walk without dropping a glass of water?” No = 1; and (4) “Have you ever tripped over an obstacle while going to the bathroom or picking up the telephone?” Yes = 1. The test–retest reliability for each item and the total points using the Kappa coefficient (k-value) and the inter-trial correlation coefficient (ICC [1.1]) between the two measurements with a 2-week interval in a sample of 312 participants were calculated as follows: Question 1 (k-value = 0.881); Question 2 (k-value = 0.816); Question 3 (k-value = 0.881); Question 4 (k-value = 0.882); and total point (ICC [1,1] = 0.941).

2.3. Data collection for other physical performance tests

The participants were subjected to five other physical performance tests that are widely used to identify high-risk elderly adults: 10 m walk under a single-task condition (ST walking)[4]; 10 m walk under a dual-task (DT) condition (comfortable walking while counting numbers aloud in reverse order starting from 50) (DT walking)[14]; a TUG test[5]; functional reach (FR)[7]; one-leg stand (OLS)[6]; and five times chair stand tests[8]. The tests were performed in a random order. For each performance task, the participants performed two trials and the average score was calculated.

2.4. Falls

Information on fall incidents within the past year was collected from participants by interview. A fall was defined as an event that resulted in a person unintentionally coming to rest on the ground, floor, or other lower level with or without loss of consciousness or injury[15]. We excluded falls resulting from extraordinary environmental factors (e.g., traffic accidents or falls while riding a bicycle).

2.5. Statistical analysis

Differences in the data between the falls and non-falls were analyzed by Student t test or Chi-square test. To compare physical performance in the two groups, effect sizes were calculated as follows: (faller mean − non-faller mean)/standard deviation. The relationship between the total point and the six previously validated tests was assessed using Spearman’s correlation coefficient. The utility of the total points used to distinguish fallers from non-fallers was tested using receiver operating characteristic (ROC) curves for cut-off points on the index. Data were registered and analyzed using the Statistical Package for Social Science (Windows version 18.0).

3. Results

Of the 780 study participants, 203 (26%) reported at least one or more falls within 1 year of administering the new index. Based on these self-reported incidences of falling, the participants were divided into two groups: fallers and non-fallers. The demographic characteristics of the two groups are summarized in Table 1. No significant differences were observed between the groups for age, body weight, height and gender. Fallers scored significantly more points in “Question 1” (odds ratio = 2.79, 95% CI; 1.94–4.03), “Question 2” (odds ratio = 3.20, 95% CI; 1.64–6.24), “Question 3” (odds ratio = 2.14, 95% CI; 1.46–3.15), “Question 4” (odds ratio = 3.46, 95% CI; 2.50–4.87), and total points than non-fallers ($p < 0.001$).

Table 1
Comparison of demographic characteristics and measurements in fallers and non-fallers.

	Faller (n = 203)	Non-faller (n = 577)	Odds (95% CI)	*E/S*	*p* value
Age	76.8 ± 8.1	75.0 ± 8.3			0.180 [a]
Weight, kg	57.9 ± 9.9	54.3 ± 11.6			0.406 [a]
Height, cm	155.7 ± 10.3	157.4 ± 11.6			0.071 [a]
Gender, female	122 (60.1%)	358 (62.0%)			0.560 [a]
Q1 (0,1) [c]	70 (34.5%)	91 (15.8%)	2.79 (1.94–4.03)		<0.001 [b]
Q2 (0, 1) [c]	19 (9.4%)	18 (3.1%)	3.20 (1.64–6.24)		<0.001 [b]
Q3 (0, 1) [c]	55 (27.1%)	85(14.7%)	2.14 (1 .46–3.15)		<0.001 [b]
Q4 (0, 1) [c]	115 (56.7%)	157 (27.2%)	3.46 (2.50–4.87)		<0.001 [b]
Total points (0–4)	1.27 ± 0.86	0.61 ± 0.88		0.77	<0.001 [a]
ST walking time, sec	10.45 ± 2.46	9.48 ± 2.59		0.39	<0.001 [a]
DT walking time, sec	14.17 ± 4.73	12.75 ± 4.76		0.30	<0.001 [a]
TUG, sec	9.90 ± 2.26	9.05 ± 2.22		0.37	<0.001 [a]
OLS, sec	6.43 ± 8.67	9.82 ± 12.60		0.39	<0.001 [a]
Functional reach, cm	23.83 ± 6.98	26.06 ± 7.90		0.32	<0.001 [a]
Five chair stand, sec	11.45 ± 5.94	9.92 ± 3.63		0.26	<0.001 [a]

[a] Student t test.
[b] Chi-square test.
[c] Q1: “Can you stand up without a support?” Yes = 0, No = 1; Q2: “Can you turn in the opposite way, while holding an empty glass?” Yes = 0, No = 1; Q3: “Can you walk without dropping a glass of water?” Yes = 0, No = 1; Q4: “Have you ever tripped over an obstacle while going to the bathroom or picking up the telephone?” Yes = 1, No = 0.
DT = manual-task; OLS = one-leg standing; ST = single-task; TUG test = Timed Up and Go test.

All physical performance tests demonstrated that the elderly participants in the non-faller group had significantly lower scores than those in the faller group. The largest effect size was the total point in all measurements. The results for total points was weakly, but significantly, correlated with those for ST walking time ($r = 0.179$, $p < 0.001$), DT walking time ($r = 0.421$, $p < 0.001$), OLS ($r = -0.154$, $p < 0.001$), and functional reach ($r = -0.083$, $p = 0.021$).

The ROC curve for the total points for the classification of fall incidents is shown in Fig. 1. The area under the curve was 0.715 ($p < 0.001$, 95% CI; 0.675–0.755). The ROC curve analysis enabled us to indicate the positive value of 1 point (sensitivity 80.8%, specificity 60.6%) and negative value of 2 points (sensitivity 0.394%, specificity 83.4%).

4. Discussion

In this study we have demonstrated that our new index is a reliable indicator for falls in elderly people who have higher levels of functional capacity. The results of the total score on the new index were moderately correlated with those of DT walking time. Moreover, the total new index score demonstrated statistically significant difference between faller and non-faller groups. Therefore, the new index may be considered a measurement that is related to walking ability under DT conditions. These results implicate the role of the total score in the fall risk assessment. A

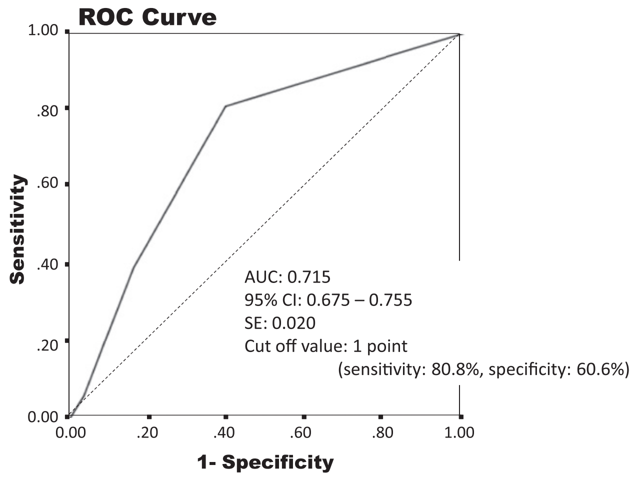

Fig. 1. The receiver operating characteristic (ROC) curve for the total points used for the classification of fall risk. The area under the curve (AUC) was 0.715. Concerning the total points, the cut-off value was determined at 1 point (sensitivity, 80.8%; specificity 60.6%).

score of 1 point by the new index was considered to represent the fall-related cut-off value. In addition, the total score on the new index had the largest effect size in the other screening tool for falls. Therefore, the index may be useful as a screening tool for fall prediction in robust community-dwelling elderly people.

The total points on the new index were weakly correlated with previous validated performance tests. The concept of the new index was assessed to complex-task locomotion related to falls. Therefore, it is not surprising that the new index was weakly correlated with simple performance tests.

In addition to the benefits of the new index as a clinical assessment tool[4–8], we assessed whether this index could be used as a tool for fall risk screening. The new index has a number of advantages over conventional fall risk screening tests. First, it takes a shorter time for the measurement. Second, it is easy to do the assessment in non-clinical settings. However, there is a limitation in this study. The new index could not predict falling in older adults as this study was based on the participants having experienced falls in the previous year. A prospective cohort study to further evaluate the relationship between fall incidents and the new index, in addition to a comparison with existing indices, is being planned.

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